DOCUMENT RESUME

ED 428 962 SE 062 332

AUTHOR Ford, Barbara; Klicka, Mary Ann
TITLE The Effectiveness of Individualized Computer Assisted Instruction in Basic Algebra and Fundamentals of Mathematics Courses.
INSTITUTION Bucks County Community Coll., Newtown, PA.
PUB DATE 1998-00-00
NOTE 29p.
PUB TYPE Reports - Research (143)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Algebra; Community Colleges; *Computer Assisted Instruction; *Individual Instruction; Mastery Learning; *Mathematics Instruction; Mathematics Skills; *Remedial Instruction; Two Year Colleges
IDENTIFIERS Bucks County Community College PA

ABSTRACT

An individualized Computer Assisted Instruction (CAI) mastery learning format was offered to sections of Fundamentals of Mathematics and Basic Algebra courses over four semesters (two academic years). The effectiveness of this method compared to a traditional lecture approach was examined in the areas of passing the course, passing the final examination, course retention, and passing the next math course. For the Fundamentals course, no significant differences were found among methods in all of the above areas except course retention; course retention was significantly higher in traditional sections. In the Basic Algebra course, traditional sections had significantly higher pass rates and course retention rates. CAI sections had significantly higher exam pass rates. Discussion and recommendations are also included. Contains 15 references and 9 tables. (Author/WRM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

SE

ED 428 962

The Effectiveness of Individualized Computer Assisted Instruction in Basic Algebra and Fundamentals of Mathematics Courses

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
M Klicka
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Barbara Ford, M.A.
Mary Ann Klicka, M.Ed, DevEd.S.

Developmental Education Services
Bucks County Community College
Swamp Road
Newtown, PA 18940

Fall, 1998

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Bucks County Community College

SE062332

BEST COPY AVAILABLE

Abstract

An individualized Computer Assisted (CAI) mastery learning format was offered to sections of Fundamentals (MATH 090) and Basic Algebra (MATH 095) over four semesters (two academic years). The effectiveness of the method compared to a traditional lecture approach was examined in the areas of passing the course, passing the final examination, course retention, and passing the next math course. For the Fundamentals course, in all of the above areas except course retention, no significant differences were found among methods. Course retention was significantly higher in traditional sections. In the Basic Algebra course, traditional sections had significantly higher pass rates and course retention rates. CAI sections had significantly higher exam pass rates. Discussion and recommendations are included in this report and further study is encouraged.

(Keywords: Computer assisted instruction; computer assisted instruction in developmental education; developmental education; computer assisted instruction in remedial education; computer assisted instruction in higher education; computer assisted instruction in mathematics education; individualized education; individualized instruction; mastery learning; algebra; developmental programs; mathematics instruction; two year college students mathematics education research)

INTRODUCTION

Background

The comprehensive and well-established Developmental Education program at Bucks County Community College in Newtown, PA, exemplifies the best of current practice in the field of developmental education. It contains all program components that have been identified with student success. These components according to the review of the literature conducted by Boylan, Bliss, and Bonham (1997) are:

presence of centralized program organizational structure

presence of mandatory assessment of students

presence of mandatory placement of students

availability of tutorial services

availability of tutor training

availability of advising/counseling services, and

presence of program evaluation.

In addition to these components of a fully effective developmental program, the Developmental Education Services (DES) program includes the integration of reading, writing, mathematics, and study skills in all developmental education courses; the mentoring of part-time faculty; alternative delivery methods of instruction; consultation services for faculty and staff across the campus; and outreach to county high schools, civic organizations, and businesses.

Problem

The program is evaluated regularly and systematically to strengthen it. Therefore, in order to better meet students' needs alternative delivery methods are researched, designed and implemented in some course sections. One such delivery method offered is a computer assisted individualized instruction and mastery learning approach in some sections of Fundamentals of Mathematics (MATH 090) and Basic Algebra (MATH 095). To see if a student's learning style was related to course success, a learning style inventory was also administered. This report will provide information about this delivery method and its effectiveness.

Individualized instruction using mastery learning seems more efficient. Students are able to concentrate on only those topics which have not been mastered. Since mathematics is a linear learning process, this mastery is important to a student's success in the next level course. Also this delivery approach allows students to work at their own pace and to even complete the course before the traditional end of the semester. An added benefit for this institution is that more Developmental Education Services (DES) courses/sections are offered because of the additional classroom space made available when these individualized mathematics sections meet in a computer lab rather than in DES classrooms. In addition to these benefits a review of the literature which follows supports the offering of computer assisted individualized instruction/mastery learning in some course sections of MATH 090 and MATH 095.

Review of the Literature

For many centuries individualized instruction was available only to children of wealthy parents who could afford this highly effective method of instruction. Results of studies done in the 1980's showed substantial positive effects of a one-to-one teacher-student ratio on student achievement (Glass et al.,1982; Bloom, 1984). One major reason for this effectiveness is that it uses individualized instruction, a documented effective alternative to the traditional lecture method. Individualized instruction is suitable to a diverse student body, since it is designed to meet a student's needs. If the student learns quickly, another task is taught and assigned; if not, the teacher can diagnose the problem, try another explanation, assign more practice and spend more time assisting the student. While setting high academic standards, the individualized method of instruction promotes effective learning in students who differ widely in their learning styles and ethnocultural backgrounds.

Because providing a one-to-one student-teacher ratio was, and still is, impossible and because the effectiveness of the lecture method was questioned, schools used small group instruction sometimes known as ability grouping. Despite small group methods, some students were still unable to succeed. Assignments appropriate for one student were not appropriate for another. Studies showed that the brightest students in the usual classroom were capable of learning much more and at a faster pace than presented (Gage & Berliner, 1988). Educational innovators began trying to find ways to get as close to a one-to-one ratio as possible in the typical one-to-thirty ratio classroom. This effort resulted in individualized instruction. Generally, individualized instruction sets each student to work on tasks appropriate to his or her particular needs, uses techniques and styles appropriate to the student's temperament, and moves each

individual ahead at his or her own rate. Some of these strategies for providing individualized instruction are: programmed instruction (Skinner, 1954), mastery learning (Bloom, 1968), personalizing systems of instruction (Keller, 1968), contracting systems, and computer assisted instruction. Since this study was conducted at a college and used computer assisted instruction and mastery learning to achieve individualized instruction, a review of the literature was done only in these areas.

Computer Assisted Instruction (CAI) makes possible programmed instruction which presents students with content, requires the student to respond actively, and immediately gives the student information about the correctness of the response. CAI has the additional advantages of:

storing, retrieving, and statistical processing of student(s) response information almost immediately.

providing the instructional program via a network to many students in different locations at the same time.

collecting information about student response time to each item.

presenting materials in auditory and video forms.

being accessible because of the widespread popularity of desk-top computers

The drawback to CAI is that the computer cannot engage in dialogue with the student nor is it cost effective (Levin, 1986). However, Kulik (1985, in Gage & Berliner, 1988) pulled together quantitatively the results of scores of studies involving CAI in general. His overall conclusions were that:

1. students' average scores on final examinations improved from the 50th percentile rank without computers to the 61st percentile rank with computers.

2. students' average retention of what they learned improved from the 50th percentile without computers to the 57th percentile with computers.
3. students with computers used about 32 percent less time in learning their lessons.
4. students' attitudes toward their classes improved to about the 61st percentile.
5. students' attitudes toward computers were more favorable than those of about 63 percent of students who learned without computers. Thus experience in using CAI made students like computers more.
6. students' attitudes toward the subject matter were unchanged.

While Kulik's results ranged from elementary to college/adult levels and included both individual and group use of computers, a study conducted later at Brenau College specifically involved developmental mathematics students. When final examination results were compared between lecture prepared students and self-paced lab prepared students in algebra, a statistically significant difference in favor of the lab students was shown (Robinson, 1990). The self-paced lab did not use computers but a math textbook and one-to-one interaction with an instructor who required mastery learning (mastery of prerequisite material before the student was exposed to new content.)

All individualized instruction which incorporates mastery learning concepts and strategies is designed to take into account individual differences among learners in such a way as to promote each student's fullest cognitive and affective development. This is done by manipulating either the learning time allowed each student and/or the quality of the instruction through various feedback/learning corrective devices.

According to James H. Block (1971), the results from over forty studies indicate that

mastery learning has marked effects on student cognitive and affective development and their learning rate. "In general, mastery strategies enable about three-fourths of students to learn to the same performance standards as the top fourth of students learning under conventional, group-based instructional approaches. The strategies seem to be especially effective for those students who typically have had problems learning under ordinary instructional conditions." With mastery learning, students express greater interest in and have a better attitude toward the material learned than with the traditional approaches. Mastery of the earliest units in a subject facilitates the learning of the subsequent units. Since mathematics involves a linear learning process (concepts build on prior ones), using mastery learning makes sense, especially in college.

As early as 1941, a series of longitudinal studies concluded that the use of diagnostic examinations and remediation to individualize instruction was an effective way to teach arithmetic and algebra. Thompson (1941) claims that the method was effective because: "1) no pupil wasted time working on topics he had previously mastered; 2) the student did not have to wait for his whole class; and 3) no student left any particular topic until he had thoroughly mastered it." Kenneth Collins (1969) studied the effectiveness of mastery learning in freshman mathematics classes at Purdue University and found that, through mastery learning, significantly more students were able to achieve an A or B course grade in modern algebra and calculus than those who were not required to use mastery learning in their courses.

. Cox (1990) identified variables which accounted for a successful grade in a remedial community college mathematics laboratory. Pretests scores (whole numbers, ratio & proportion,and algebra), student's age, and the Asset test scores were significant predictors. Gender, time of attendance (day or evening), and attitude were shown to be independent of the

grade in the course. On the other hand, Bangert, Kulik and Kulik (1983, p. 152) found that studies involving individualized systems of instruction in the college setting contributed significantly to student self-esteem, critical thinking ability, and attitudes toward the subject matter, in addition to significantly affecting student achievement. This was not found true for students in high school. College students are more mature and are better prepared to work under conditions of independence and freedom.

However, since not all students have developed the self-management required by individualized instruction even at the college level, individualized instruction may not be the best method of instruction for these students. This study was conducted to examine the effectiveness of individualized instruction via the computer in Fundamentals of Mathematics (MATH 090) and Basic Algebra (MATH 095) course sections.

Purpose

Several purposes prompted this approach. Students who came into the course familiar with some of the material could move through it quickly and then concentrate on their areas of weakness. (This even opened the possibility of completing the course before the end of the semester.)

Students who needed additional time to learn particular material (often those who, in a traditional class, would fail a test and still need to move on to the next chapter and end up further behind) would be able to take the time needed for practice before being required to take a test. Students would also have the opportunity to re-test after doing further study/work, if they did not achieve mastery of the material.

Students who did not complete all required chapters by the end of the semester and

needed to register for the course the next semester could continue from where they left off. These students, in a traditional repeated class, would often spend time in the beginning of the semester on material they have already mastered and then need to move quickly through the more difficult material.

Many students taking these basic courses have a high level of anxiety both in studying mathematics and in taking tests. It was hoped that encouraging students to schedule tests when they felt prepared to do so might increase their confidence in taking math tests and also increase their achievement.

An additional advantage of this approach in the classroom is that the instructor can spend individual time with students requiring help with particular topics while students working independently can continue without interruption.

The advantage of students' becoming familiar with computer tutorials (which are available outside of class time) is that, in the absence of an instructor or tutor, a student has another means of having problems explained and practiced with immediate feedback.

In general, the goal was to provide an additional means for students to master a required course, using methods which fit their particular learning style.

Limits

Since individualized computer assisted instruction in mathematics would not be appropriate for all students, only a few sections using this delivery method would be offered each semester (less than 25% of the offered course sections in MATH 090 and less than 8% in MATH 095). However, the offering of these sections depends on faculty who volunteer to do individualized instruction and administer the learning styles inventory. Given that the union

contract assures academic freedom, regardless of any positive results of the study, the continuation of this alternative deliver method would depend solely on an instructor's prerogative.

This study can not be considered truly post-facto because only a two year period transpired. Neither is this study truly "experimental." Students and instructors could not be randomly assigned to traditional and control groups. Therefore, levels of significance are meaningless. Also, there was no control over instruction in non-individualized sections. While instructors involved in individualized instruction met regularly and made joint decisions, instructors in the "traditional" sections did not. Regardless, the results over two academic years could be obtained and reported for informational purposes.

Population

The students in both developmental math courses are typical of the population of this community college. The majority are under twenty-five years old. This was true of the students in this study. There was no noticeable difference in ages between those students enrolled in the individualized sections and those enrolled in the other sections.

There were 543 students (subjects) in this study. Students are required to enroll in these courses as a result of their performance on the institution's mathematics placement test. A passing grade of C or better in the course allows the student to progress to the next level mathematics course.

Importance of the study

Developmental Education Services has traditionally endeavored to provide students with the basic skills prerequisite to success in college level courses. As part of its efforts to meet the

needs of individual students, the program continues to explore various delivery methods of instruction. The offering of another delivery method to developmental math students further meets the needs of this diverse population. In addition to the advantages listed in the "Purpose" section above, the information gathered may motivate other Developmental Education Services faculty to volunteer to teach the individualized sections. Many faculty members are now using this study's learning styles survey in their classes for the student's own educational information.

PROCEDURE OF THE STUDY

CAI Description

In the Fall 1996 semester, three sections of MATH 090 were offered in an individualized, computer-assisted, mastery learning format. (These sections are referred to as "CAI non-lecture".) These three sections were assigned to two instructors. During this first semester of the study, an attempt was made to see if there was any relationship between success in the CAI course and a learning style preference. No relationship was found, so the question was not pursued in the remainder of the study.

The individualized format of the CAI non-lecture sections allowed for self-pacing. Students requiring more or less time on a topic could progress at a pace different from classmates. The instructor provided both general instruction and individual tutoring in the classroom setting. The class met in a computer lab and used the textbook's computer software for guided instruction and practice problems. (Textbook instruction and practice was also provided.) The mastery learning format provided that students progress to the next chapter only

after they had achieved an 85% mastery on the previous chapter test. For those unable to achieve the mastery level, further textbook assignments, videos, or Tutoring Center appointments were made according to the student's learning preference. Retests were then given and this cycle was then continued until the mastery level was reached. There was no retest on the final exam.

Three sections of CAI non-lecture MATH 090 were again offered in Spring 1997, one section in Fall 1997 and one in Spring 1998.

A number of students requested that Basic Algebra be offered in the same format. Therefore, the offerings expanded to include three sections of MATH 095 (Basic Algebra) in Spring 1997, one section of MATH 095 in Fall 1997 and one in Spring 1998.

In the Fall 1997 and Spring 1998 semesters, a variation on the traditional lecture approach was offered. For a total of three sections of MATH 090 and one section of MATH 095, a lecture class was held in a computer lab and the same textbook software used in the non-lecture classes was used as a required supplement to the class lectures.

The same two part-time instructors taught the CAI lecture and CAI non-lecture sections throughout the course of the study.

Method of Analyzing Success

The current study of the CAI non-lecture method did not set up a controlled experimental situation, but rather, collected data concerning the effectiveness of an individualized CAI approach. The purpose was to examine the method's effectiveness, according to the following criteria:

1) Of those receiving a final grade, the percentages of students passing the course

(with C or better);

2) Of the students in the class after drop/add, the percentages of those who did not withdraw (course retention)

3) Of those who took the computer-scored, departmental final examination, the percentages of those with a passing grade on the final exam (C or better)

4) Of those taking the exam, the percentages of those receiving a grade of A or B in the computer-scored departmental final examination;

5) Of those taking the next math course, the percentages who passed with C or better;

6) Of the students passing the course, the percentages of those who were retained as BCCC students the next semester

All students who took MATH 090 and MATH 095 were included in the data. Those in traditional lecture approach classes were included in one group and those in CAI non-lecture and CAI lecture were two separate groups.

Since students registered for these classes as they normally do, many uncontrolled variables exist within both the groups of traditional classes and the CAI classes. Factors such as class time lengths, instructor, personal level of motivation and maturity, personal study skills, and peer influence can all affect conditions of learning. Within smaller groups of students (ex. CAI totals), these variables could be even more significant.

One particular section, however, which also has a distinctly different approach to instruction, is the distance learning section of each course. Given that the distance learning students are instructed through videos and textbook, do not attend classes on lessons, are self-paced to the extent of setting their own appointments for tests (within a time range), and do the

majority of their course work independently, these classes appear to share more features with the CAI non-lecture classes than they do with traditional lecture classes. For this reason, it was useful to examine the distance learning section (for the same two courses over the same four semesters) as a separate approach.

STATISTICAL RESULTS

The results of the collection of data are included in the tables at the end of this report. For each of the two courses, the six criteria were examined for each semester, and a summary table is given which includes the four semester totals. Some of the approaches were used less than four semesters and this is noted. Some of the samples also included very small number of students. Results include total number of students and percentages of students for each criterion.

Results of the four semester totals were then examined (chi-square analysis) for significant differences among the methods. In the MATH 090 course, no significant differences were found between the traditional sections and any of the other CAI methods, using the criteria of passing the course, passing the exam, achieving an A or B on the exam, passing the next math course, or college retention. Significant differences ($p=.001$) did occur in course retention between traditional and CAI non-lecture sections, and also between traditional and distance learning sections, with traditional sections having significantly higher course retention. Differences in course retention between CAI non-lecture and distance learning sections were not significant.

In the MATH 095 course, no significant differences were found between the traditional

sections and any of the other methods, using the criteria of passing the next math course, college retention, or passing the exam with an A or B. Significant differences were found between traditional CAI non-lecture sections in passing the course ($p=.01$) and course retention ($p<.001$), with traditional sections having the higher percentages. Traditional sections also had significantly higher course retention than distance learning sections. Significant differences were found in passing the final exam ($p=.05$), with CAI sections and distance learning sections having higher pass rates.

DISCUSSION AND CONCLUSION

In observing the actual progress of the course, several things are worth noting. Self-pacing did occur. Some students moved through early material quickly, although only two students in the four semesters of the study completed the course early.

Students did re-test to achieve mastery. As they moved through the course, they often became more adept at knowing when they were adequately prepared to pass the test.

Most students who took two semesters to complete the CAI non-lecture course did not withdraw, as advised. (By withdrawing from the course, the student could continue coming to class and progressing, but a W would appear on his/her transcript.) Instead, their grade shows an F for the first semester and a passing grade later. Although taking two semesters to pass a course is common even among students in traditional classes, in the CAI non-lecture sections, it is one of the options in the original design of a self-paced, mastery learning approach. Therefore, counting these students twice does somewhat distort the statistics. A more realistic picture could be obtained by counting these students only once. Thus, these figures were

adjusted in the summary chart.

In MATH 090, of nine students counted twice because they received an F in their first semester of a CAI non-lecture class, seven passed the course in the CAI section the next semester. Of two students who withdrew the first time, both passed it the next semester. In MATH 095, of five students counted twice because they received an F in their first semester of a CAI non-lecture class, two passed the course in their next semester.

During the four semesters considered in this study, a new option was provided which included some of the most at-risk students in the course and, therefore, could have impacted the results. This option was provided for students in the traditional sections of the course who were falling behind after their first or second test. With departmental approval, several of these students took the option of moving into the individualized CAI section. This enabled them to continue working on their weak skills during the semester, under the direction of the CAI instructor, even though they did not complete the course by the end of the semester.

Of these students, those who eventually withdrew from the course lowered the course retention numbers in the CAI sections. Those who did not withdraw and instead received a grade of F for the course lowered the passing rate in the CAI section, even though they were not originally enrolled in that section. Although these numbers were small, they caused the population of CAI students to be different from the onset. There was no way to later identify the particular students involved, so they were not accounted for in the study. The option, however, did continue throughout the four semesters, since it did meet the particular needs of some of the most at-risk students; this was judged in the long term to be the higher priority.

Due to the nature of the CAI sections, several factors in the instructional method differed

from the traditional approach. In the MATH 095 sections, one of these differences was the textbook. The text used in the CAI sections was chosen based on the user-friendly tutorial software which accompanied it, and which was integral to the design of the class. The text, however, was generally, acknowledged to be more challenging for students than the text used for the other sections. This presented another factor whose effect was not measured.

One of the factors working against the CAI non-lecture results in this study was the higher student withdrawal rate (i.e. lower course retention.) In this college, however, withdrawal rates are not used in institutional research to measure course success; therefore, the significant findings regarding withdrawal rates in the CAI non-lecture sections are not that important. This institution values college retention rather than individual course retention.

If, according to the statistics, the final exam scores in MATH 095 show that CAI and distance learning students have learned more, one might question why this difference does not show up in the next level math course. One possible reason could be that mastery learning works well for the current course; but, in the next course which, in the spiraling nature of the curriculum, reviews and builds on previous topics, perhaps mastery learning is not essential.

Recommendations

The purpose of any approach to instruction is to provide the means for students to be successful in their learning. Since students vary widely in their needs and in the background they bring to a course, no single approach is best for every student. An approach need not be effective for all students, or even the majority of students, in order to be valid. If several methods are similarly effective in their results, it would seem reasonable to try to direct students to the approach which may work best for them. Herein lies the problem.

Students generally choose a class which fits into their time schedule, unless they have reason to seek out a particular instructor. Despite the CAI designation of these course sections (which did not mention individualized learning), it was found that most students were unaware that the course involved computers. When informed of the specific individualized nature of the course and given the opportunity to change sections, many students were reluctant to change into another section. Therefore, the self-selection process which would direct to these classes those who might benefit most was absent.

One possible attempt to refine the self-selection process in CAI non-lecture classes might be to specify, as is currently done with distance learning classes, that these classes are for self-motivated, independent learners.

Other possible refinements to the method might include: varying the mastery levels of some topics or skills which may not be the most critical to success in the next course; and the exploration of an alternate grading (such as NR) for the semester in which a CAI course is not completed (in order to avoid a student's carrying an F grade on the transcript).

In conclusion, the individualized, computer-assisted, mastery learning approach to MATH 090 and MATH 095 has been shown to be effective, particularly in the areas of passing the next math course and college retention and, additionally with MATH 090, in passing the course and the exam. For these reasons, it can be recommended that the course sections using this delivery approach continue to be offered on the same limited basis. However, given that there was no significant differences in most of the criteria, does the CAI non-lecture format merit the additional time, energy, organizational, and fiscal (i.e. cost of computer labs) demands necessary to deliver this course? Much depends upon whether or not faculty and administrators

choose to provide this type of flexible instructional system for the benefit of students.

MATH 090 - 4 Semesters Totals
Student Success Data in %

	Traditional		CAI non-lecture		CAI with lecture		Distance Learning	
PASSED 090[1]		*(4)		(4)		(2)		(4)
	225/294	77	57/85	67	25/36	69	20/29	69
PASSED[2] EXAM		(4)		(4)		(2)		(4)
	204/248	82	47/55	85	23/31	74	21/23	91
PASSED EXAM With an A or B[3]		(4)		(4)		(2)		(4)
	165/248	67	35/55	64	15/31	48	17/23	74
COURSE RETENTION[4]		(4)		(4)		(2)		(4)
	294/335	88	93/123	76	36/43	83	29/42	69
COLLEGE RETENTION[5]		(3)		(3)		(1)		(3)
	137/177	77	41/50	82	20/21	95	15/17	88
PASSED NEXT MATH[6]		(3)		(3)		(1)		(3)
	52/98	53	15/28	54	8/16	50	8/10	80

*indicates number of semesters of data

1 Of those who received a final grade in MATH, the percentage who passed the course with a C or better.

2 Of those who took the final exam, the percentage who passed the exam with a C or better.

3 Of those who took the final exam, the percentage who passed the exam with an A or B.

4 Of those who were enrolled in the class after add/drop, the percentage who received a final grade.

5 Of those who passed MATH 090 with a C or better, the percentage who were retained as students at BCCC for the next semester.

6 Of those who took the next sequential math course, the percentage who passed the course with a C or better.

MATH 090 - Fall 1996
Student Success Data in %

	Traditional		CAI non-lecture		Distance Learning	
PASSED 090	73/93	78	25/32	78	9/11	82
PASSED EXAM	63/76	83	24/24	100	9/11	82
PASSED EXAM With an A or B	55/76	72	19/24	79	7/11	64
COURSE RETENTION	93/102	91	32/50	64	11/13	85
COLLEGE RETENTION	56/73	77	21/25	84	8/9	89
PASSED NEXT MATH	25/44	57	10/17	59	3/4	75

MATH 090 - Spring 1997
Student Success Data in %

	Traditional		CAI non-lecture		Distance Learning	
PASSED 090	57/68	84	19/35	54	5/8	63
PASSED EXAM	54/61	89	15/18	83	6/6	100
PASSED EXAM With an A or B	41/61	67	11/18	61	5/6	83
COURSE RETENTION	68/74	92	35/41	85	8/11	73
COLLEGE RETENTION	45/57	79	16/19	84	5/5	100
PASSED NEXT MATH	12/31	39	4/9	44	4/4	100

MATH 090 - Fall 1997
Student Success Data in %

	Traditional		CAI non-lecture		CAI with lecture		Distance Learning	
PASSED 090	47/64	73	6/16	38	21/29	72	3/5	60
PASSED EXAM	44/52	85	4/6	67	20/26	77	3/3	100
PASSED EXAM With an A or B	34/52	65	2/6	33	13/26	50	2/3	67
COURSE RETENTION	64/80	80	16/17	94	29/35	83	5/10	50
COLLEGE RETENTION	36/47	77	4/6	67	20/21	95	2/3	67
PASSED NEXT MATH	15/23	65	1/2	50	8/16	50	1/2	50

MATH 090 - Spring 1998
Student Success Data in %

	Traditional		CAI non-lecture		CAI with lecture		Distance Learning	
PASSED 090	48/69	69	7/10	70	4/7	57	3/5	60
PASSED EXAM	43/59	73	4/7	57	3/5	60	3/3	100
PASSED EXAM With an A or B	35/59	59	3/7	43	2/5	40	3/3	100
COURSE RETENTION	69/79	87	10/15	67	7/8	88	5/8	63
COLLEGE RETENTION	*Not Available		Not Available		Not Available		Not Available	
PASSED NEXT MATH	Not Available		Not Available		Not Available		Not Available	

*Due to date of study

Math 095 - 3 Semesters Total
Student Success Data in %

	Traditional		CAI non-lecture		CAI with lecture		Distance Learning	
PASSED 095	793/1105	* (3) 72	30/55	(3) 55	5/11	(1) 45	24/36	(3) 67
PASSED EXAM	490/856	(3) 57	22/29	(3) 76	6/7	(1) 86	21/24	(3) 88
PASSED EXAM With an A or B	287/856	(3) 34	10/29	(3) 34	4/7	(1) 57	15/24	(3) 63
COURSE RETENTION	1105/1266	(3) 87	57/78	(3) 73	11/17	(1) 65	36/49	(3) 73
COLLEGE RETENTION	455/544	(2) 84	16/21	(2) 76	NA		14/16	(2) 88
PASSED NEXT MATH	207/309	(2) 67	6/12	(2) 50	NA		6/7	(2) 86

*number of semesters of data

MATH 095 - Spring 1997
Student Success Data in %

	Traditional		CAI non-lecture		Distance Learning	
PASSED 095	197/274	72	14/34	41	9/13	69
PASSED EXAM	137/238	58	12/13	92	7/9	78
PASSED EXAM With an A or B	78/238	33	7/13	54	5/9	56
COURSE RETENTION	274/308	89	34/45	76	13/17	76
COLLEGE RETENTION	153/197	78	10/14	71	8/9	89
PASSED NEXT MATH	69/100	69	4/8	50	1/2	50

MATH 095 - Fall 1997
Student Success Data in %

	Traditional		CAI non-lecture		Distance Learning	
PASSED 095	347/515	67	7/12	58	7/11	64
PASSED EXAM	174/381	46	3/7	43	6/7	86
PASSED EXAM With an A or B	90/381	24	1/7	14	2/7	29
COURSE RETENTION	515/601	86	12/17	71	11/17	65
COLLEGE RETENTION	302/347	87	6/7	86	6/7	86
PASSED NEXT MATH	138/209	66	2/4	50	5/5	100

MATH 095 - Spring 1998
Student Success Data in %

	Traditional		CAI non-lecture		CAI with lecture		Distance Learning	
PASSED 095	249/316	79	9/11	82	5/11	45	8/12	67
PASSED EXAM	179/237	76	7/9	78	6/7	86	8/8	100
PASSED EXAM With an A or B	119/237	50	7/9	78	4/7	57	8/8	100
COURSE RETENTION	316/357	89	11/16	69	11/17	65	12/15	80
COLLEGE RETENTION	*Not Available		Not Available		Not Available		Not Available	
PASSED NEXT MATH	Not Available		Not Available		Not Available		Not Available	

*due to date of study

References

Bangert, R. L., Kulik J. A., & Kulik C. C. (1983). Individualized systems of instruction in secondary schools. Review of Educational Research, 53 (2), 143-150.

Block, J. H. (1971). Mastery Learning: Theory and Practice. New York: Holt, Rinegart & Winston.

Bloom, B. S. (1968). Learning for mastery. Evaluation Comment, 1(2). Los Angeles: University of California Center for the Study of Evaluation, 465-466.

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of instruction as effective as one-to-one tutoring. Educational Researcher, 13, 4-16.

Boylan, H., Bliss, L., & Bonham, B. (1997). Program Components and Their Relationship to Student Performance. Journal of Developmental Education, 20 (3), Spring, 1997, 2-8.

Collins, K. M. (1969). A strategy for mastery learning in freshman mathematics. Unpublished manuscript, Purdue University, Division of Mathematical Sciences.

Cox, G. L. (1990). Characteristics Related to Student Performance in a College Remedial Self-Paced Mathematics Laboratory. Lake Michigan College. (ERIC Document Reproduction Service No. ED 316 422).

Gage, N. L. & Berliner, D C. (1988). Educational Psychology. Dallas: Houghton Mifflin, 455-482.

Glass, G., Cahen, L., Smith, M. L., & Filby, N. (1982). School class size. Beverly Hills, CA: Sage.

Keller, F. S. (1968). Good-bye, teacher. Journal of Applied Behavior Analysis, 1, 49-58.

Kulik, J. A. (1985). Consistencies in findings on computer-based education. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Levin, H. M., & Meister, G. (1986). Is CAI cost-effective? Phi Delta Kappan, 68, 745-749.

Robinson, P. W. & Morgan, J. A. (1990). A study of the self-paced math lab approach to developmental algebra compared to the traditional lecture method at Brenau. Brenau College, GA. (ERIC Document Reproduction Service No. ED 328 452).

Skinner, B. F. (1954). The science of learning and the art of teaching. Harvard Educational Review, 24, 86-97.

Thompson, R. B. (1941). Diagnosis and remedial instruction in mathematics. School Science and Mathematics, 41, 125-128.

ABOUT THE AUTHORS

Barbara A. Ford, M.A., is a part-time instructor and mathematics resource specialist in Developmental Education Services at Bucks County Community College, Newtown, PA. She has been teaching courses in Fundamentals of Mathematics, Basic Algebra, and Intermediate Algebra for eleven years. Prior to this, she was a junior high school mathematics teacher. In 1998, she was awarded the National Association for Developmental Education Adjunct Faculty Development Award.

Mary Ann Klicka, M.Ed., is Director of Developmental Education and a Professor in Developmental Education Services at Bucks County Community College, Newtown, PA. She has taught developmental courses there since 1982 and was appointed director in 1994. Previously, she pioneered computer assisted instruction in her junior high classes for the Perceptually Impaired in the Florence Township, NJ public school system, where she taught for fourteen years. In 1989 she received the NJ Governor's Award for Excellence in Teaching. In 1998, under her direction, Developmental Education Services at Bucks County Community College was awarded the Pennsylvania Association of Developmental Educators Outstanding Program Award.